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Since computers appeared on the commercial market in 1950, computer technology has become a necessary part of modern education, both as subject matter and as an aid for teachers and administrators. Despite its potential however, high costs and prejudice have delayed acceptance by educators. An effort, therefore, must be made to overcome misunderstandings which obscure the benefits of computers in education. Computers can aid rather than replace the teacher, not only by handling the enormous amounts of paperwork involved in registration, keeping records, scheduling, and administrative tasks, but also by serving as a library for data retrieval and by aiding in counseling and grading papers. By relieving teachers of paperwork, computers could allow more time for planning classwork and for individual sessions with students. The high cost of instructional programs is a major factor in inhibiting innovation, but linkups with regional computer networks could make it possible to share costs as well as benefits. Such linkups could make it possible for even the poorer schools to provide flexible, individualized instruction and offer courses which would otherwise be unavailable to their students. (RM)

# COMPUTERS: New Era for Education?

EDUCATION U.S.A. SPECIAL REPORT

# This Is an EDUCATION U.S.A. Special Report

Since it was founded in 1958, *Education U.S.A.* has introduced several new dimensions to educational journalism in the United States. Its weekly newsletter on education scans major developments in preschool to graduate level education. The editors select from hundreds of sources, including reports from their own correspondents in each state, what seems most significant or interesting for the newsletter's readers. The *Washington Monitor* section is a current report on activities at the U.S. Office of Education, Capitol Hill, and other federal agencies involved in education. Every year the editors prepare a special handbook of articles on trend-making subjects in American education, *The Shape of Education.*

Occasionally, the editors decide that some aspects of education are important enough to be covered in detail through special reports. This is the seventh report of this type. Others have reported on problems confronting school boards in an era of conflict; the impending technological revolution in education; significant happenings at the 1966, 1967, and 1968 national conventions of the American Association of School Administrators; and the 1967 amendments to the Elementary and Secondary Education Act.

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EDUCATION U.S.A.

SPECIAL REPORT

# COMPUTERS: New Era for Education?

## EDUCATION IN THE COMPUTER AGE

The first computer was put on the commercial market in 1950. Now, just 18 years later, leaders in government, business, and education are warning that any student who doesn't receive some background in computer technology during his school career is getting a second-class education.

Already a familiar part of the equipment in business and government, the computer has been slower in making its appearance on the education scene. However, the numbers of computers used for educational purposes are multiplying at a fast rate, especially on college campuses. According to the American Council on Education, the 600 colleges and universities that had computers in 1966 will increase to 1,100 by 1970. Information available from the Association for Educational Data Systems shows 800 school districts with computers in 1966, with a prediction of 1,600 districts by 1970.

More dramatic than the growth in numbers of computers is the growth in the ways in which computers are being used to help solve the problems of education. In schools and laboratories across the country, experiments are being conducted that will make the school of tomorrow almost unrecognizable from the school of today.

The five-year-old who enters kindergarten will have his registration papers processed by a computer. When he graduates years later, he will receive a diploma or degree prepared by a computer. In between, the computer will assist in teaching him, counseling him, scheduling him into classes, testing him, grading his papers, helping him with homework, and providing his report cards. As he struggles through reading and arithmetic, the computer will be his patient tutor. If he needs information, he can not only consult his local library but also "retrieve" materials instantaneously from other libraries in the United States and eventually in the world. With the help of the computer, he will be able to solve complex problems that formerly were assigned only to more advanced students.

When he is trying to decide on a vocation or college, the computer will help him explore the different alternatives and suggest the training he will need. The versatile computer can provide teachers and administrators with a printed record of student progress on each lesson, so they can determine where to make curriculum revisions. It can simulate a school in operation to help the educational planner anticipate the consequences of alternative courses of action.

As computers become widespread in education, they are creating issues that educators must tackle. What will be the role of the teacher in the computerized classroom? How is educational information provided by the computer to be used? Who should pay for the costly development of computer facilities?



U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

## A NEW LOOK FOR DICK AND JANE

For the first grader in East Palo Alto, California, the classroom "desk" consists of a television-like screen surrounded by an array of machinery. There is a typewriter keyboard for his fingertips, an electronic pen for his hand, a screen to his left that shows color slides, and an earphone and speaker for his head--all linked to a computer.

A picture of a paper bag flashes on the screen, while the words "rag," "bag," "rat," and "bat" appear on the TV tube and recorded instructions over the earphones tell the student to select the word that best describes the picture. The student can indicate his response by touching his pen to the word on the tube, typing out his selection, or answering audibly.

If he's right, a smiling face appears on TV and the earphones say, "Good. Bag. Do the next one." If he's wrong, the face frowns, while the voice says, "No. The word that goes with the picture is bag. Now touch and say bag."

The computer running this operation is located at Stanford University, whose Institute for Mathematical Studies in the Social Sciences has been conducting research and development in computer-assisted instruction (CAI) since 1963.

In September 1966, Stanford opened the nation's first computerized elementary school classroom at the Brentwood School located in a low-income, largely Negro neighborhood in East Palo Alto. One hundred first and second graders are taught reading or mathematics daily with the help of a computer.

The children spend 30 minutes a day at the machine. The computer keeps track of each student's work, feeding him new material as his skills increase or holding him back for additional drill if he is having difficulties. A daily report is printed out, listing the lessons each child has completed, so teachers and school officials can keep close tabs on the students' progress.

The results so far are impressive. A first-year evaluation showed that the computer-taught reading group performed significantly better than did the students taught by regular classroom methods. The five- and six-year-olds were able to solve about 75 simple reading problems per hour, with the fastest student managing more than 161 problems per hour.

One of the most significant findings was that the boys did as well as the girls in reading. Professor Richard C. Atkinson, co-director of the project, attributes the boys' success to "removal from the normal classroom social milieu to the asocial environment of a CAI tutorial system."

"The suggestion has been made many times," Atkinson said, "that differences (between performance of boys and girls) might be attributed, at least in part, to the social organization of the classroom and the value and the reward structure of the predominantly female primary grade teachers."

Atkinson also concluded that in a computer environment, "the sex difference is minimized in proportion to the emphasis on analysis rather than on

rote memorization in the learning task"--in other words, boys and girls can be taught equally well to analyze rather than learn reading by constant drill, even in the earliest years.

"The one problem type in which the girls achieved significantly higher scores than the boys was the word-list section, which is essentially learning to pair associated words," Atkinson added.

Stanford now has a computer network which supplies instructional material to more than 1,000 children in 32 schools throughout the country. Besides six schools in the Palo Alto area, students in 13 Mississippi schools and 13 Kentucky schools are receiving lessons daily via teletype circuits from the computer at the Stanford laboratory.

Another Stanford professor, Wolfgang Kuhn of the music department, has had favorable results in using a computer to teach pitch to singers. With a specially developed "pitch extraction device," the computer can evaluate musical tones, distinguish between male and female voices (which it translates as "high" or "low") and detect deviations of as little as half a percent from perfect pitch.

When a student is ready to practice with the computer, a tape recorder can offer him a sample pitch or he may play a series of notes on an organ-like keyboard which produces a true tone. Then he sings into a microphone the tones which the computer has printed out to the beat of a metronome. Here is how a typical music lesson might go:

"Register h or l (high or low)?" the computer asks. "H," the student responds, notifying the computer that it is dealing with a female.

"If you wish a detailed analysis of your deviation from the true pitch," the computer prints out, "strike 'ready'; otherwise enter the criterion you

## A Species of Supermen?

New educational tools such as the computer will be able to exploit the brain's potential to the extent that a new species will evolve, predicts Ralph W. Gerard, professor of biological sciences and dean of the graduate division at University of California's Irvine campus.

He pointed out that many experiments on animals have proved that it is possible to modify the structure of the brain and other parts of the nervous system by altering the kind of experience to which the animal is exposed. He noted, for example, that the brain of man's ancestors grew in size enormously when they moved down from the trees and were forced to cope with new environmental experiences on the ground. Similarly, Gerard said, computers might bring about further changes in man's brain by "offering the first real opportunity for tailoring experience to the individual child."

wish to be used in terms of the percent deviation as ½ percent, 1 percent, 2 percent, 4 percent."

"Two percent," she replies. After explaining the procedures for the test, the computer commands, "Ready? Sing."

A correct pitch would result in a response of "OK" from the computer. Or the computer might even say "Congratulations!" if success were achieved.

In an experiment with undergraduate music students, Kuhn reported, the computer gave an erroneous report of pitch only once in 10,000 tries. "Each note in the performance was sampled," he said, "and the pitch analyzed. The computer decided whether a specific exercise was to be repeated, or whether the student should go forward in the program or repeat similar material for more practice."

The computer's sense of pitch, Kuhn noted, "is better by several orders of magnitude in both accuracy and reliability than would be expected from human judgment." He foresees the day when the computer will be used to teach students to play musical instruments.

The near perfect "ear" of the computer also makes it a valuable tool in teaching foreign languages. At the University of Michigan, for example, students learn foreign language pronunciation from a machine. The computer listens to them talk, analyzes their speech for pitch and rhythm, and shows them how they compare with the ideal pronunciation of a native. Stanford is also experimenting in the field of foreign languages, with undergraduate students learning beginning Russian.

One of the most advanced centers of computer-assisted instruction is located at Florida State University. Here experimentation is being conducted with computer curriculum for both college and elementary school courses.

Last fall 23 freshmen participated in what is believed to be the first accredited college course fully taught by computer. The course was introductory physics for nonscience majors. Conducted under a U.S. Office of Education grant, the experiment was designed to compare the effectiveness of a computer with the lectures of a professor.

The content of the computer course was the same as that taught to more than 500 other freshmen in regular classroom lectures. But instead of attending lectures, the CAI students went to the computer center for three hours each week to "converse" with a machine.

In directing the instruction of the physics students the computer would jump students who were progressing quickly and provide hints or remedial work to those having difficulty. It would direct students to reference materials and audiovisual aids and, of course, assign homework.

The CAI students were graded on the same mid-term and final examinations as were the regularly taught students. The College Entrance Examination Board has looked into the project and granted the University funds to investigate the possibility of computer-based testing.

The new "professor" has made introductory physics one of the most popular courses on campus for the social science and humanities majors who formerly dreaded it. More than 98 percent of the University's nonscience majors now want to enroll in the computer course, which is presently undergoing review and evaluation.

Duncan Hansen, director of Florida State University's computer-assisted instruction center, points out the potential impact of his research. It may produce a self-contained, fully automated basic physics course which could be made available to colleges and universities where there are too few students to form a class or where there is a shortage of physics professors. Similar projects are in operation at Pennsylvania State University, University of Illinois, University of Michigan, and University of California (Irvine).

Terminals can be installed on any campus and linked with a computer at the other end of the country, with courses transmitted via communication networks similar to the Stanford network in operation. The computer could also allow professors to teach large classes on an individual tutoring basis, for the hours spent in lecture could be turned over to small group discussions.

The Florida State University computer is also participating in the development of new seventh- and eighth-grade science materials. The Intermediate Science Curriculum Study (ISCS) is working on courses that are strongly laboratory oriented and designed to allow each student to move at his own pace through a curriculum adjusted to his ability. While 12,000 students in nine states are field testing the first draft of the materials, 16 seventh graders are being exposed to a computer version of the same course.

Across the hall from the computer center is a small laboratory stocked with the same equipment that all other classes in the ISCS trial are using. Here the student sets up his apparatus and obtains the data or other information needed to answer the questions posed by the computer. Behind the scenes, electronic devices are recording data on tape to give a complete record of student progress: how much time the student spends on each lesson, the number of times he goes back to reexamine earlier material, and the answers he gives to questions. This computer classroom is generating feedback that will suggest needed improvements in the courses.

## You Look Different, Doctor

At the University of California's Langley Porter Neuropsychiatric Institute, a computer is helping to train future psychiatrists. The computer has been programmed to conduct clinical interviews with medical students. It can play either the patient or the psychiatrist, thus giving the students experience on both ends of the interview.

Efforts have been made to simulate a real clinical situation. When playing the role of the psychiatrist, the computer will maintain an analytic deadpan and respond with silence or a simple "go on" if necessary to draw the patient out.

## THE IMPLICATIONS OF CAI

What are the advantages of the computer as a teacher? First, the computer can provide more individualized and flexible instruction. As Sylvia Charp, editor of the Association for Educational Data Systems Monitor and director of instructional systems for Philadelphia City Schools, puts it:

"The pace and sequence of materials can be independently controlled for each student, based on his responses to the materials. Brighter and faster students can move rapidly from one topic to the next with a minimum of repetition and redundancy, while the slower student can be given all the extra work he needs to bring him up to the required level of performance.

"The student will not be bored by repetitious drill on material already mastered nor will he be discouraged by new material before he has mastered a previous topic."

Each student sitting before his own personal console is, in effect, receiving instruction from a private tutor using instructional materials designed specifically for him.

Another way the computer helps provide individual attention is by taking over the drill and practice exercises, thus allowing the teacher more time to work with students who need his help. Furthermore, the computer can drill for hours without succumbing to human frailities, such as fatigue or losing one's temper.

The computer can provide more refined information as to how students learn, thus greatly facilitating the solution of one of education's thorniest problems--evaluation of the effectiveness of instructional programs. The present tendency is to examine a course over a semester or a year, which tells the teacher where the student stands at the end, but gives little information on how he arrived there.

By breaking up a course into small units, computer-assisted instruction lends itself more amenably to evaluation. Information regarding different units can be systematically collected so that decisions can be made as to which units are more effective for what kinds of students at what point in their development.

The computer can provide continuous monitoring of the student's learning process and provide immediate feedback on his progress. The computer's capabilities for generating information on student learning make it an important aid in curriculum development. By detecting student difficulties or ease with different units of instruction, the computer assists in identifying needed course revisions.

In the realm of testing, the computer can insure that each student receives the same test instructions in the same tone of voice and takes the same amount of time to complete the test. It can also skip large blocks of questions that are obviously too easy or too difficult for the student.

The computer can help to equalize educational quality in different

schools. With a terminal linked to a computer, a poor school in a rural area will eventually have access to the same quality of teaching and diversity of curriculum that a wealthy suburban school can provide.

The computer may succeed with some students where a teacher would fail --simply because it is a machine, says R. Louis Bright, associate commissioner for the U.S. Office of Education's Bureau of Research.

"Computers are effective teachers for illiterate adults who may feel too humiliated to take advantage of what educational opportunities they have," Bright said. "The computer can't embarrass them; it deals with them individually with no critical human eye to watch their performance....

"In educating the handicapped, the machine can make its communication with the blind entirely verbal; with the deaf, entirely visual. There are psychological advantages: experiments dramatically show that some emotionally disturbed students who reject humans will relate to hardware."

Bright also noted the computer's advantages as a "contingency reinforcer." "It can reward a student immediately for work well done. If the lesson is too tough for him, it prescribes material where he can be successful.

"This instantaneous reward technique shows striking results in motivating both adults and school-age students from disadvantaged families. It can boost confidence and utterly change personalities in children who have rarely experienced even the smallest success or received a reward for academic work."

Bright predicts that computers will be ready for massive use in elementary and secondary schools in three or four years. Patrick Suppes, co-director of the Stanford computer research project, envisions that within a few years "millions of school children will have access to what Philip of Macedon's son, Alexander, enjoyed as a royal prerogative: the personal services of a tutor as well informed and responsive as Aristotle."

Yet, despite the optimism over the computer as a teaching tool, the fact is that it has yet to make significant inroads into America's classrooms.

A recent survey by the National Education Association showed the computer is being used for instructional purposes by only 1.4 percent of public school teachers. It has a long way to go before competing with the silent filmstrip projector or even yesterday's revolutionary device, educational television.

Most experts agree that if computers are to be put to maximum use in the classroom the number one factor to overcome is misunderstanding on the part of many educators as to what computer-assisted instruction will mean.

"The field of education suffers significantly from both fear of computer omnipotence and lack of imagination regarding computer utility," says John I. Goodlad, dean of UCLA's Graduate School of Education. Added to the general lack of enthusiasm over the prospects of automation that many members of the public share are the inhibiting factors in education that have not affected other enterprises to the same degree.

"E ucation is above all an activity conducted by and for humans," Goodlad said. "...It is considered one of the professions. Connotations of the concepts, 'human' and 'professional,' are such that automation of any part of education appears to be somehow degrading and suspiciously dehumanizing."

Martin Greenberger, professor of computer sciences at Johns Hopkins University, places the blame on the tendency of the computer's proponents and opponents to overstate their cases.

"The computer, less than 20 years since its appearance upon the commercial scene, is still a relative stranger to our times," Greenberger said. "Strangers tend to look gray to us (at best) and our inclination is to want to make them black or white. In old movies of Africa, the natives either welcome the stranger as their savior and make him king, or they blame him for all their troubles and set him on the coals.

"So it is with the computer, which is crowned by some and cooked by others."

The computer's abilities are overstated by phrases such as "electronic brain," "giant thinking machine," and "mechanical wizard," and denigrated by misleading appraisals such as "it can't do anything it isn't shown how to do" or "it has the mentality of an idiot," Greenberger said. While some think it can do anything a human can do, others think of it as a "glorified slide rule."

In the last analysis, Greenberger said, the question of whether the computer is a hero or villain is a question about men, not machines. What influence the computer has depends on man's control.

According to the experts, the computer will aid, not replace, the classroom teacher. That is why it is called "computer-assisted instruction" (or computer-based instruction, or computer-assisted learning, or computer-prescribed instruction), rather than computerized instruction.

"Books have been in widespread use in the schools only since the end of the 1800's," Suppes observed. "Despite what people said, they put no one out of a job. Neither will computers."

But the role of the teacher will be drastically changed. The teacher of tomorrow has been described as a classroom manager, a physician instead of a pill dispenser. His primary job will no longer be that of presenting information. He will be free of many of the monotonous tasks that now consume much of his school day, such as drilling students, correcting tests, or keeping track of paper work.

Instead, the teacher can devote more time to diagnosing individual learning problems, leading small group discussions, developing his students' creative skills, helping them with communication skills and social relations, developing and coordinating the use of curriculum materials, and, in general, serving as an inspirational model.

The teacher, then, will be concentrating his time on doing the things a computer can't do. His responsibilities will be upgraded, demanding more

skills, not less effort. Said U.S. Commissioner of Education Harold Howe II:

"A computer cannot develop a student's ability to associate effectively with other people. It cannot train a pupil to originate ideas, to present them and defend them against criticism, or to talk confidently before a group. It cannot foster creativity, stimulate thought, encourage experimentation, teach students to analyze."

There are still technological problems to be faced in using computers for instructional purposes. The computer must be much more reliable when its users are school-age children than when its users are sophisticated scientists or experienced engineers. As Suppes pointed out, when children are put at computer terminals and the machines don't work as they should, the result is chaos.

However, the primary bottleneck in the development of computer-assisted instructional systems is not in the hardware, but in the software--the programs for the computer. At present there are more and better machines available than materials to put into them.

Estimates are that it takes about 40 hours of human labor to develop one hour's worth of instructional materials for the computer. John W. Hamblen, president-elect of the Association for Educational Data Systems and director, Computer Sciences Project, Southern Regional Education Board, prices the development costs at $300,000 per course.

The personnel costs of running a computer already exceed the cost of the hardware. Hamblen believes that if computer-assisted instruction is to make inroads, educational institutions must be prepared to spend $7 on personnel--mostly for development and testing of new materials--for every

## The Use of Information

When individualized instruction becomes a reality, one of the major challenges will be how to handle and intelligently use the mass of data that a computer can compile on each student's performance. According to Patrick Suppes of Stanford, the data output can run to 1,000 pages a day when 5,000 students use the computer terminals. Educators faced with using the information to make decisions about instruction are aware of the inadequacy of their knowledge, he said.

"The power of the computer to assemble and provide data as a basis for such decisions will be perhaps the most powerful impetus to the development of education theory yet to appear," Suppes said. "It is likely that a different breed of education research worker will be needed to feel at home with these vast masses of data. The millions of observational records that computers now process in the field of nuclear physics will be rivaled in quantity and complexity by the information generated by computers in the field of instruction."

$2 on hardware. Thus, the research and development aspects of CAI would account for about 75 percent of total costs.

With these figures, Hamblen acknowledges that there are not going to be too many developmental centers established, especially by educational institutions. "CAI cannot have a significant impact on education at any level until there has been an expenditure in excess of $1 billion by public and private enterprise in curriculum software research and development," he said.

The biggest underwriter of research and development has been the U.S. Office of Education. To date, the Office has spent approximately $34 million for research, planning, and operational projects dealing with the application of computer technology to education. Most of the efforts have been in the last two and a half years since the passage of the Elementary and Secondary Education Act of 1965.

About $10 million in federal funds is being currently spent for 58 projects in computer-assisted instruction under Titles III and IV of ESEA and Title VII of the National Defense Education Act. In addition to math and science courses, research is being conducted in areas such as speech and language therapy, reading, electronics and auto mechanics, music, and foreign languages.

Because of the interdependence of course materials and machinery, both of which are costly, Hamblen believes that manufacturers will probably market the hardware and software as a package. "It is useless for the computer manufacturers to produce special CAI equipment unless there are course materials readily available, and heavy expenditures for course materials cannot be justified if there is no equipment on which to use them," he said. The course materials, he predicted, will be used to sell the machines, at least for the first 10 years.

## EDUCATION IN COMPUTER TECHNOLOGY

The computer not only assists in teaching, but it also is a subject to be taught. According to the President's Science Advisory Committee, "an undergraduate college education without adequate computing is deficient education, just as undergraduate education without adequate library facilities would be deficient education."

Yet, the Committee found, in 1965 less than 5 percent of the total college enrollment--all located at a relatively few large, rich institutions, had access to computer services and training adequate for their educational needs. In its report, "Computers in Higher Education," the Committee warned that unless the deficiency in computer education is made up quickly, millions of students who will have attended college in the 1970's will be poorly prepared for the world of the 1980's and 1990's.

Where adequate facilities have been available, the Committee said, computers have become a part of more and more undergraduate courses, including business subjects, social sciences, biological and health sciences, psychology, and geology, as well as mathematics, physics, chemistry, and engineering.

"This is consistent with the rapidly growing use of computing outside the schools in small as well as large business enterprises, in government operations and national defense facilities, and in almost all technology--those many fields of endeavor where most college graduates will find their places," the Committee reported.

"Computing is not an esoteric or specialized activity; it is a versatile tool useful in any work with a factual or intellectual content. Computing is becoming almost as much a part of our working life as doing arithmetic or driving a car.

"In all fields where computing has been used, it has added a new dimension to education, and has led the students to better comprehension of complex problems and greater insight into the meaning of quantitative expressions. In these areas undergraduates have learned, through preparation and experimentation with computer problems, of the care required to define a problem logically and fully, and the assumptions needed to obtain answers to complex problems."

Despite the low percentage of college students who now receive computer education, the Committee predicted that by the 1970's only a small percent of the college enrollment will graduate without having made some use of computers.

The cost of providing adequate computer service would average $60 per student per year, or about 4 percent of the operating budget of colleges and universities. This would amount to about $400 million per year for the nation by 1971-72. The Committee recommended that the federal government share part of the cost of providing computer education in colleges and universities.

At a few colleges a majority of students receive computer education as part of normal course work. An example is Dartmouth College, where rudiments of computer programming are introduced in freshman and sophomore mathematics. During a 10-week term each student spends three quarters of an hour a week at a computer terminal and an equal amount of time planning programs.

The President's Science Advisory Committee also recommended that all high school students be taught about computers. "Training in the use of computing and in the nature of computers and computing is rapidly but randomly invading secondary education," the Committee reported. "The advantages of introducing the use of computing into course work and of teaching something about the nature of computers in secondary schools can be considerable, either as a preparation for college work, as a preparation for semiprofessional or vocational training, or as a preparation for employment. Such training in secondary schools will increase rather than decrease the amount of educational computing required in colleges and universities."

The most common subject taught around computers--besides data processing itself--is mathematics. Experiments have shown that teaching students to program a computer and then requiring them to solve problems with it is effective in improving their problem-solving abilities. The success of this technique has been attributed to the need for precise, detailed, step-by-step procedures in computer usage.

A program of instruction in basic computer concepts is in operation in the Marion County (Oreg.) Intermediate Education District titled Computer Instruction Network. Each high school is assisted in designing a program of computer instruction including use of a "digital trainer" for basic logic concepts; "hands-on" use of a small portable classroom computer for teaching problem-solving techniques and programming in a very simple machine language; and access to a larger computer (installed in a mobile unit or "Computmobile") on a "scheduled visit" basis.

The number of computer education programs in the nation's schools and colleges is expected to rise, not only because of the impact of automation on the life of the average citizen, but also because of the increasing demand for computer personnel to run the machines. Educational institutions must train personnel not only for themselves but also for industry and government.

The 85,000 computers that are expected to be in operation in 1975 will almost triple the 30,800 that were in use in 1965. It is estimated that there will be a demand for 200,000 systems analysts and designers in 1975, as compared to 60,000 in 1965. The supply of programmers must increase from 100,000 to 300,000, and the number of keypunch and computer operators from 43,000 to 80,000. These demands will affect educational curricula from high school vocational programs to university doctoral programs.

A recent nationwide survey by the Southern Regional Education Board supported by the National Science Foundation showed that while 44 colleges and universities offered a bachelor's degree in computer sciences or related fields in 1965, 107 additional institutions plan to have such a degree available by 1969. By that year, 76 institutions will be offering a master's degree and 43 will have a doctoral program.

The National Science Foundation has established an Office of Computing Activities to stimulate new ideas and approaches to computer use in the research and educational processes. Its programs are intended to respond to needs of institutions, departments, and individual investigators.

## THE COMPUTER AS A COUNSELOR

"Do you plan to continue your formal education beyond high school?"

"Yes."

"What type of college do you plan to attend?"

"A state college."

"The grades you get in high school largely determine the type of college you will be able to attend. Let's just take a look at your projected high school grades based on your present performance. Students who got grades like yours in junior high did as follows in high school: 70 percent earned A or B, 20 percent earned C+, and 10 percent earned C. On the basis of your projected grades, your college choice indicates that you are thinking pretty realistically about your future life....

"Now let's think about the 12th grade. The required courses for the 12th grade are Government 2 and Physical Education. What other courses would you like to take in the 12th grade?"

"French 3 and Girls' Woodwork."

"Okay, that's a pretty good 12th-grade program. It is a good idea for all college-bound students to take four years of English. Give this some thought. I hope this interview has provided you with some information to think about in planning your high school program.

"It's been nice interacting with you. Thank you, Debbie."

This typical conversation between a student and her counselor has one distinction: the counselor is a computer. Like its human counterpart, the automated counselor listens to students' problems, helps them select a college or occupation, provides guidance on courses to take, and acts as a source of information to assist students in making realistic decisions for the future.

To develop a ninth-grade computer-assisted counseling program, System Development Corporation of Santa Monica, California, picked the brains of an experienced counselor, recording his statements and behavior as he thought out loud in analyzing student cumulative records and as he conducted personal interviews with students. From these records an automated cumulative folder appraisal system and an automated student interview structure were developed, using the counselor's verbatim statements as a model.

In studying student cumulative records, the computer produces conclusions for the counselors. The counselor may be advised:

- "Student's grades have gone down quite a bit. Ask about this in interview. Possibly there are personal problems."
- "Student should improve verbal skills. If not, student may not be able to attain desired academic goals."
- "The disparity between aptitude scores and achievement is so great that one is led to suspect the aptitude test. Look into this."
- "Should be headed for college. Encourage student to explore widely in academic areas."
- "Look out for overambitious plans."
- "Low counseling priority. No problems apparent."

In the automated interview, student and computer converse via teletypewriter. The machine types out the student's courses and grades for the previous semester and asks the student if he is having problems in his work.

Then the student's goals are explored. If he plans to go to college, the computer helps him select one. If he does not, the computer explores

with him possible vocational alternatives. Following selection of a college or vocation, the student's major field of interest is discussed. The student is given a prediction about his probable grades in high school and his chances of success in his chosen post high school career.

The computer urges the student to start thinking about his courses for high school, evaluates his choices, and advises him of required courses and the relevance of his selections to his major. At the conclusion of the interview critical information, such as problems the student is having in class, is printed out and transmitted to a counselor.

System Development Corporation's automated counselor was tested on ninth graders in Palo Alto. No significant differences were found between the human and computer counselors in identifying changes in the pattern of student grades, underachievement, overambitious plans, need for remedial work, or appropriateness of post high school plans.

However, the computer identified more students as overachievers and potential dropouts than did the human counselor. The computer was also more permissive in approving the student's choices for high school courses.

A computer-based counseling program is also being developed by a team from Harvard University, Massachusetts State Department of Education, and the New England Education Data Systems (NEEDS). The project, called "Information System for Vocational Decision," has been under way for a year and is expected to be operational in early 1969.

David V. Tiedeman of Harvard emphasizes that the computer will not make decisions for the students but instead will give them a better background of information on which to make their own career choices. "The real guidance system is developed in the student, not in the machine," Tiedeman said. While the emphasis is on career and vocational guidance, plans call for branching out into areas such as job placement, occupational forecasting, and retraining of persons whose jobs have become obsolete.

Information about jobs, industries, expenses, and educational programs is fed into the computer to be matched with data about the student's academic background, interests, and work experience. Students can consult the computer for suggested careers and required training and education.

Besides his dialogue with the computer, the student will receive additional guidance from his teachers and counselors who will help him interpret the computer's responses and help plan his career. After the computer program goes into operation, Harvard researchers plan to conduct research on how the computer influences student decisions, and the relationship between career choices and subsequent job performance.

The computer is expected to assist the counselor in using his time more efficiently. For example, an overburdened counselor may come to school in the morning to find twice as many students wanting immediate guidance as he has time to see.

He sends all the students to individual consoles or terminals, which

are connected to a computer containing each student's educational and personal records. Each student engages in a brief interview with the computer, which then sends a report to the counselor.

After scanning the report, the counselor can select the students who he feels need immediate consultation or who can benefit most from his help. From information provided by the computer, he might decide to refer other students to specialized school personnel, such as the remedial reading teacher, dean of boys, librarian, nurse, or psychologist.

With computers comes the tool for more refined measurements of student potential, thus enabling greater accuracy in counseling students as to areas in which there is the best prognosis for success. Project Talent, administered by the American Institutes for Research and supported by funds from the U.S. Office of Education, has established a data bank on 440,000 students, representing about 5 percent of the nation's enrollment in grades 9 through 12. A continuing record of these students will be maintained on magnetic tape for 20 years.

By measuring the students on 100 different traits commonly observed in adolescents and following their educational and vocational development, Project Talent researchers hope to be able to predict a future student's success in any given area by looking at his trait profile.

The traits fall into two broad categories--ability and motive. Ability traits range from spelling to hunting and fishing, with the major ones being verbal skills, English language, mathematics, visual reasoning, perceptual

## Scan and Select

A high school senior living anywhere in the country can call on a computer to help him select a college and, after he receives his degree, find a job.

To choose a college, the student fills out a questionnaire describing his background, scholastic record, interests, and financial situation. He sends the questionnaire, along with $10, to SELECT College Consulting Program, developed by a firm called K&B Associates. His data are matched by computer with 2 million items of information on 3,000 colleges in the country. SELECT sends the student and his counselor a list of 10 to 15 most ideal colleges for his particular background.

After he graduates, the student can fill out another questionnaire to take advantage of the services of SCAN, short for Student Career Automated Network. Sponsored by the College Placement Council, an organization representing 2,000 college placement directors, SCAN matches the background of graduates with the requirements of companies and agencies who are recruiting personnel. The result is to give job seekers national exposure and rapid channels of communication with potential employers.

speed and accuracy, and memory. Among the traits in the motive category are conformity, academic interests, business interests, outdoor and shop interests, cultural interests, and science interests.

Because there are 4,950 correlation coefficients describing the relationships among the 100 traits, a computer would be needed to handle the analysis of data.

Paul R. Lohnes of the State University of New York at Buffalo has proposed that the present grading and record generating practices in the schools be eliminated in favor of a computer measurement system using the Project Talent traits.

"Among the more concrete traces of a student's path through his schooling are the hieroglyphics inked on his cumulative record and his report cards," Lohnes said in a paper presented at an Educational Testing Service conference. "My contention is that the measurement record attached to students in most of our secondary schools today is inadequate and harmful; that it involves errors of commission in that it sponsors invidious comparisons, burdens teachers, and erects a barrier between the teacher and student; that it involves errors of omission in that it ignores important traits of individual differences in adolescents and it provides inadequate interpretations of the traits it does report."

The problem, Lohnes said, is that "too many teachers view students as a group phenomenon, to be treated by group practices. We need a school measurement system that makes it impossible for teachers to type students. The system would treat each student as a unique person."

The computer measurement system would encourage individuality and identity by viewing each student's potential in light of his personal profile and pointing up his strengths, Lohnes said. While the present grading system judges the student after the fact, the new system would be geared toward helping him plan his future.

"The student would be helped to locate possible goals which have high probability for him," Lohnes said. "If he holds to a goal which is known to have a low probability for him, he will be able to see which of his traits need to be modified to increase the probability. The student is helped to see the real probabilities of various goals for him, and that his future is not determined, since probabilities are a joint function of his goals and his attributes, and both are subject to deliberate change."

## BUSTED? NO SUCH WORD

Help is on its way for the harried English teacher deluged by stacks of essay papers to be corrected. Professor Ellis B. Page and his associates at the University of Connecticut have developed a system for grading English essays by computer.

In 30 seconds the computer can "read" an essay and analyze it for ideas, organization, style, mechanics, and creativity. On a trial run, using 256

papers written by students at a Wisconsin high school, the computer's judgments were practically indistinguishable from those of English teachers. The researchers are also working on a feedback system that will not only grade the essays but also comment on them much as a teacher would. Suppose the following essay were turned in:

"The name of my favorit television program is Batman. I watch it every chance I get exept last week when our TV set was busted. Then I couldn't see it.

"The week before that they had a really good show on. The Catwoman stole some jewelery she liked. She hid the stuff somewheres. I beleive that it was in her hide-out.

"Batman and Robin aint stupid so they soon found it and almost catched the Catwoman. She got away during the fight. They could have found her later but they didn't wan to give theirselves away.

"Their is other neat crooks on the program too. Like the Penguin the Riddler and the Joker.

"They are always trying to get the Dynamic Duo, but they never seem to be able to."

Here's what the computer would have to say: "I don't think that you did very well. Try harder next time and pay closer attention to what I tell you. Do you really think the past tense of 'broken' is 'busted,' or were you just careless? 'Somewheres' is an example of poor speech habits showing in your writing. The word should be pronounced and spelled without the final 's.'

"I notice you used the word 'aint.' Many people still object to it. See if your teacher allows that word before you use it again. Some verbs are irregular because they form their tenses in a strange way. 'Catch' is such a word and its past tense should be 'caught.' The word 'theirselves' should be replaced by 'themselves.' I see that you have used 'their' followed by a verb. The correct form is 'there.'

"You used 5 paragraphs. Why so many? Try to reorganize the essay so that you don't use as many paragraphs. Usually, a paragraph should consist of several sentences and should present one complete unit of thought. I noticed that you didn't use very many commas. Did you separate items in a series by commas, use commas in compound sentences, use commas after introductory phrases?

"Your sentences seem short and choppy. Combine several using appropriate connectives such as 'and' and 'or.' Here is a list of your spelling errors: favorit, exept, jewelery, beleive."

With computer grading, Page said, students may be able to have the daily or at least weekly essay writing experience they need but often don't get because of the staggering paper-correcting load this places on the teacher.

"We know that all teachers should promote the frequent and correct use

of English in their subject fields," he said. "But we don't seriously expect it, because it is just not possible in our present schools. We hate even to look at this language problem, because it is so distressing, and because there is little point in complaining about what we cannot seem to help.

"Just for a moment, then, imagine what the result would be if all student essays could be turned over to a computer, which would perform a stylistic and subject-matter analysis according to the general rules desired, and deliver extensive comment and suggestion for the student to the teacher by the first bell the next day. Surely, this seems a kind of magic today, yet a beginning system of this sort may be instituted in a very few years."

Page believes that the computer may also help solve a problem that plagues essay examinations--how to measure them with the same reliability, validity, and objectivity that are possible with multiple-choice tests. The computer's criteria for grading essays are based on an average of the independent judgments of several teachers, thus increasing the dependability of the grade.

What happens to creativity and the work of an offbeat, but gifted, student? Won't this student be overlooked by the computer? Not necessarily, says Page, at least not any more than he is now. In setting up the computer program, Page and his associates found that there was less agreement among the human experts on creativity than on other factors, such as mechanics and style. The computer's correlation with human judgments on creativity was about the same as in other areas. Thus, the computer's difficulty in determining creativity can be traced to the difficulties that humans have in deciding what is creative or original.

The University of Connecticut researchers are not worried that shrewd students will try to "psych" the computer and get good grades by putting into their essays what they think the computer is looking for. "The program may eventually become so complex and consider so many variables that the most efficient way for a student to 'con' the machine is just to write well," Page said.

Furthermore, a good computer program will be able to provide for a vast variety of individual student differences. It can evaluate each student's progress in terms of his past work and not merely in comparison with the work of other members of the class.

At present, each essay has to be key-punched before being fed into the machine, as computers cannot read handwriting. Page admits this is a problem, but he believes it will not be for long. Many college classes already require students to type their essays, and optical scanners can then read typed characters, and convert them to machine usable information.

"Someday," he said, "we may realize the great advantages of teaching early reading and writing by using electric typewriters--or preferably, other powered, cheap and noiseless character-printers not yet in production. When each student has his own printer and the skill to use it, and is therefore emancipated from the slow, messy, and cumbersome problems of penmanship, the computer-input problem will be ideally solved."

## THE PAPER PUSHER

The major application of computer technology in education is in the area of administration. Increasingly, school systems are turning over such tasks as student records, payrolls, personnel files, class scheduling, and inventories to a computer.

One of the largest and most comprehensive computer systems is operating in the Chicago schools where information on more than 600,000 students and 600 schools has been automated since 1960. Chicago administrators estimated that their teachers had been spending from 20 to 35 hours per month on non-instructional tasks--and this didn't include grading papers. In a city the size of Chicago, the time spent by teachers on clerical work was the equivalent of about 5,000 positions.

By inserting the proper codes, a Chicago administrator can receive a report depicting the financial condition of each school. A materials file will tell him the supply of textbooks on hand as of that morning. A facilities and organization file will answer his questions about the number of seats in a classroom, the number of laboratories or band rooms, the adequacy of the lighting, the square footage of the playground area, the number of teachers needed to teach a particular subject in a particular school, etc.

Complete cumulative records on each student, from the time he entered the Chicago school system to the day he graduates, are maintained on computer tapes. As Chicago has thousands of students who may attend as many as six schools in the first five weeks of school, one of the main advantages of the computerized records is to speed up the flow of information as students transfer from one school to the next. An optical scanner can pick up a teacher's mark on an attendance sheet and feed it into the computer, which prepares and updates 20,000 class rosters on a regular basis.

Before the computer came along, each school principal plastered his walls once a year with maps showing every street, railroad track, and alley in his area. Then he went to his student files and pinpointed every student on the map. Hundreds of such maps were brought into the central office, where one big map was prepared to form the basis for deciding what changes were to be made in attendance zones and where new schools were to be built.

Chicago has since put on magnetic tape a map of the city, street by street. Matching the map with data from the automated student and facilities files, the computer has made educational planning and decision-making less laborious for the Chicago administrator. The computer can also schedule 150,000 high school students for classes in a weekend, record grades on standardized tests, and tell the business office what, when, how much, and where to order supplies.

Chicago uses its computer center around the clock, with teaching and research functions scheduled during the day and administrative functions at night. Data processing classes are available for high school students in the 11th and 12th grades. The machine is also used for inservice education, where school personnel from administrators to clerks learn various aspects of computer operations and programming.

Chicago with its 600,000 students may be able to buy comprehensive computer services, but how can a small district afford to automate its operations? The answer, some specialists say, is regionalization. One computer can be shared by a number of school systems and colleges.

A U.S. Office of Education study shows that if several schools use the same computer facility, it would cost an average school district no more than one percent of its total budget to take advantage of several important computer applications. The school district would receive administrative services and its students would receive the opportunity to learn modern data processing techniques.

Even if a school system could afford a small computer, such a machine could not perform some of the more complex tasks that a school district occasionally has, such as modular class scheduling which usually requires a sophisticated computer. By pooling resources, a number of districts can have the level of services that none of them could afford individually.

An example of regional cooperation is the New England Education Data Systems (NEEDS), a nonprofit organization which started in 1960 and now serves 80,000 students in more than 50 school districts and six state departments of education. Associated with Harvard Graduate School of Education, NEEDS receives financial support from the Ford Foundation and the U.S. Office of Education as well as from its members.

NEEDS maintains a pupil master file, with individual cards containing basic information on each student. Data from the cards can be retrieved for the key services that NEEDS provides--attendance accounting, student scheduling, test grading and analysis, and preparation of report cards. The master file can also be used to produce materials such as school directories and address labels.

In addition to administrative services, NEEDS is moving into the research and instructional areas. Besides the Tiedeman counseling project, the organization is conducting a two-year study to evaluate the effectiveness of educational programs in New England financed by Title I of the Elementary and Secondary Education Act.

Many of the local school districts are also turning to NEEDS for research assistance on their federally funded projects. The computer was used to help one district obtain data on students with failing grades so that a remedial project could be developed, while in another area NEEDS analyzed student recreational interests in preparation for a school district's application for a federal grant.

The regional approach, either within a state or among states, is rapidly developing in many parts of the country. Thirteen states have combined to form the Midwestern States Educational Information Project; its purpose is to develop and implement a data system on students, finances, personnel, facilities, and instructional programs.

Another regional project involves the State University of Iowa, the Iowa State Department of Public Instruction, and a number of local school

districts. Besides speeding up routine administrative tasks, plans call for a study of the environmental influences on student achievement, including teacher preparation, pupil-teacher ratios, and student backgrounds. The computer will also assist Iowa educational planners by providing services such as enrollment and financial projections, and building utilization studies.

The two states with the largest population--California and New York--are establishing regional computer centers that will cover all their public schools. Both states plan to use the centers, in part, for research and development of model systems illustrating use of computers in education. It is estimated that approximately 25 regional centers are now in operation or have been funded, either locally or with federal assistance.

At the national level, the U.S. Office of Education has designed a system whereby any authorized user can dial a telephone number and communicate directly with a computer in Washington, D.C., to ask for information. The request is transmitted by a teletype machine hooked onto the user's telephone, and the answer comes back in 2 to 30 minutes. Or, if the user asks for too much information, the computer informs him that his answer will be sent by mail.

Already incorporated into the central file are applications and year-end reports on Elementary and Secondary Education Act, Title I, projects, a portion of the data collected in the Higher Education General Information Survey, and a comprehensive summary of the data gathered in the Equal Educational Opportunity Survey, which resulted in the Coleman Report. The latter file contains socioeconomic background and achievement data on 575,000 elementary and secondary students, plus information on their teachers and schools.

Federal officials are now formulating policies regarding use of the files. Priority is expected to be given to state departments of education and other governmental organizations involved in educational research. A few machines have already been authorized to use the system.

## THE COMPUTER AS A GUINEA PIG

In the school of the future, an innovation might be old by the time it is tried on the students. It will have been tested by a computer first.

Through simulation, the computer can aid in school management and decision-making by acting out a plan and informing the administrator of the consequences. In a few minutes, the computer can go through a procedure that would normally take a full year's time and thus enable educators to try out radical innovations without suffering the potentially harmful results. In addition to exploring the feasibility of new ideas, the computer can point out needed improvements in existing activities.

Major work in the area of computer simulation has been done by the System Development Corporation (SDC), which designed a program using computers to help solve one of education's biggest problems: how to organize instruction to be more sensitive to the individual needs of students. In a

study involving several schools, the computer analyzed the changes that individualized instruction would make on:

- Role and use of personnel
- Effect of new instructional media on pupil-pupil and pupil-teacher relationships
- Use of data processing
- Arrangement and use of facilities
- Characteristics of graduating students.

One of the schools SDC worked with was Garber High School in Essexville, Michigan. The combined junior and senior high school was contemplating a fully individualized mathematics program, in which students could move through as many as six years of course work in mathematics at their own pace. The school offered 29 different math courses, ranging from practical math to calculus, with parallel versions of some courses to accommodate different ability levels of students.

A model of 900 students going through Garber's math curriculum was designed, taking into consideration the characteristics of individual students, their learning speed, the various "paths" they could take after finishing each course, and the factors influencing their decisions. The activities of the students, such as receiving help from the teacher, taking tests, studying in small groups, and being referred to a counselor, were entirely reproduced on the machine.

As a result of the simulation study, Garber administrators were told to expect that 745 of its 962 students would be enrolled in mathematics courses at the end of six years, while 217 would drop math along the way. Some of the courses would have no enrollment, while others would have such a mixture of students from different grades that the teachers in those courses must be prepared to deal with a wide range of age groups.

The administrators were advised to establish a complex bookkeeping and

## Counteracting Impersonalization

At many student demonstrations, the computer has been the center of attack as a symbol of the growing impersonalization of large universities. Yet, a computer may actually increase a university's ability to give each student the classes he wants.

When Purdue University changed over to a computerized class scheduling system, students got their first choice of professors about 78 percent of the time, as compared to 22 percent under the old manual system.

information processing system, as individualized learning would result in 30 to 40 students transferring from one course to another on any given day, and 300 examinations would have to be given daily as students finish a unit of work. Variations in learning rate would be such that teachers must be equipped to help students on any part of a course at any time.

Student group patterns, the computer predicted, would require that 33 classrooms be available, plus space where 25 students could be tested simultaneously. Finally, the simulation showed, when Garber students graduate they will have taken an average of 4.9 mathematics courses.

At another high school in Theodore, Alabama, SDC demonstrated the use of computer simulation to suggest improvements in existing curriculum. The computer replicated a biology course in which 100 students worked on their own with programmed instruction materials.

Teachers were present to give individual assistance to students having difficulties understanding the course content, but there were no lectures or group presentations. Individual learning was somewhat restricted, however, by a requirement that every student had to be at a certain point in the study guide at the end of each quarter in the school year.

The computer simulated the existing course and also an experimental course in which the time constraints were lifted. The results showed that by extending the course seven weeks and eliminating the "milestones" that students had to meet, student performance would be increased by more than 30 percent.

After its studies at Garber, Theodore, and three other high schools, System Development Corporation concluded that individual instruction on a large scale will not be a reality without the help of a computer to keep track of student progress.

"At any one time," the report said, "all students may be working on different points in the curriculum. Each student's need for help from the teacher may be different. Every day a few students may be taking tests. A great deal of teacher time is devoted to monitoring and evaluating student performance.

"One reason the lockstep system has persisted for so long may be that the method is designed to reduce the information processing problems of the teacher. Students progress in unison, take tests simultaneously, and are given identical assignments."

If a school system is to have maximum individualized instruction, SDC concluded, student time and school resources--such as curriculum materials, teacher assignments, and facilities--must be scheduled on a day-to-day basis. Teacher assignments, for example, would be based on the requests for assistance that students turned in the previous day. This is being done by Glenn Ovard at the Brigham Young University Laboratory School, Provo, Utah.

With the current progress in computer technology, "it is now technically feasible to develop information processing centers in schools that continually

accept requests for resources by students and teachers, and that develop schedules for the use of resources," SDC said. "These schedules would make optimal use of the resources."

## EDUCATING THE EDUCATOR IN THE COMPUTER AGE

Last year a group of deans of schools of education met at a conference called by the Association for Educational Data Systems. Their topic: how to train teachers and school administrators for the computer age.

The conference report noted: "It is neither sufficient that we merely 'come to terms' with the inevitable merger of the conventional educational methodologies and the computerized educational technologies nor that we make just a conscientious effort to be conversant with the current trends and anticipated developments in the field of computer-assisted instruction and educational technology.

"Our motivation may be engendered by academic self-interest or by concern for the various interest groups that would ultimately benefit from the development of an adequate course of study and training. In either instance, it is equally imperative that educators systematically organize, implement, and administer a nationwide instructional program in educational data processing for effective and efficient use at every level of academic and industrial activity."

Computer technology not only will affect the educators who specialize in it but also will influence the work of teachers, administrators, business managers, curriculum supervisors, and counselors. The deans at the conference urged that public school administrators have at least a conceptual understanding of the computer and that every school system have at least one administrator who understands the technical aspects.

Unless a large number of school superintendents and public school officials are trained or retrained in the use of computers, the conference concluded, the significant administrative problems caused by both the hardware and the software will likely result in an inefficient allocation of human and financial resources.

"The crucial task of blending hardware, software, manpower, and administrative needs falls squarely on the shoulders of the educational administrator and secondary school superintendent," the conference report stated. "Moreover, the difficult task of enlightening the public as to myth and reality in education computing is usually another responsibility of the school administrator.

"Educational researchers and administrators should know as much about the capabilities of the computers as the technicians and should take the lead in discerning and selecting the appropriate uses to which educational technology can be put. This means that the school superintendent must not only be able to understand the equipment and the computer specialists but he must also be able to use them efficiently."

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